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THE SHARP-HEADED GRAIN LEAFHOPPER.

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INTRODUCTION.

The sharp-headed grain jassid or leafhopper (*Draeculacephala mollipes* Say) has long been known to infest cereal and forage crops, principally grains and grasses. It is probably one of the most commonly observed insects of the farm, ranging throughout practically the entire United States. However, as Prof. Herbert Osborn remarks,[1] "it seems to have received much less notice from the economic standpoint than it merits."

The observations and facts set forth in this paper are the result of an entire year's work on the species in the Salt River Valley of Arizona during 1914, together with occasional observations elsewhere. With these data have been included the results of various miscellaneous observations made by other assistants engaged in cereal and forage insect investigations in the Bureau of Entomology.

The most extended account of this species previously published is included by Prof. Herbert Osborn [1] in Bulletin 108 of the Bureau of Entomology, and the aim of the present paper is to supplement Prof. Osborn's excellent treatise from which the author has freely quoted. The sharp-headed grain jassid was described by Say in 1831, mentioned by Dr. Asa Fitch in his list of insects in 1851, and was commented upon by Prof. P. R. Uhler in 1884. Prof. H. Garman describes it as a corn pest in 1890 in the second Annual Report of the Kentucky Agricultural Experiment Station, and Prof. Osborn gave an account of the species in Bulletin 22, Division of Entomology, U. S. Department of Agriculture, and in 1891, 1892, and 1897 added materially to the knowledge of the species, his account in 1912 being the last published treatise on the species.

[1] Osborn, Herbert. Leafhoppers affecting cereals, grasses, and forage crops. U. S. Dept. Agr., Bur. Ent., Bul. 108, 123 p., 29 fig., 4 pl., Sept. 12, 1912. See p. 56.

NOTE.—This paper is of interest to entomologists throughout the United States.

ECONOMIC IMPORTANCE AND MODE OF INJURY.

The economic importance of the Jassidæ has never been fully appreciated by the farmer and planter, nor have these insects been given the attention which they deserve, even by entomologists. Especially is this true of the sharp-headed grain jassid, one of the most widely distributed species with a great variety of food plants. While it probably may not become a destructive pest over wide areas, there is always the possibility of local outbreaks which may cause serious injury and temporary losses, as exemplified by the attack upon 180 acres of corn on the farm of Dr. O. R. Stewart, Palatka, Ark., during July, 1912. It no doubt occurs in small numbers every year over its entire range of distribution and causes secondary injury to grain and pasture grasses by attacking vigorous growing plants, hindering and interfering with their growth and development, and already weakened and unhealthy plants, hastening their death or permanently dwarfing them.

The greatest damage inflicted by the sharp-headed leafhopper is to young and tender grain crops by the feeding of nymphs and adults during the fall and early spring months. To corn and other crops the greater damage is done during the summer months. Because alfalfa is of such rapid growth the apparent injury to the crop will probably always be very slight.

There are three classes of injury, the most important of which is the direct injury caused by the feeding of nymphs and adults, in puncturing leaf and stem tissue and sucking the juices therefrom. An occasional feeding puncture in a leaf or stem would not of itself do appreciable harm, but when there is a concentrated attack upon a plant by from 10 to 50 nymphs or adults the injury becomes appreciable. In many instances the author has observed leaves withered throughout from this cause. The early stages of injury are indicated by a yellowing of the tissue around the feeding punctures, which are in themselves so small as to be hardly visible to the naked eye. Following the yellowing there is a drying and deadening of tissue which turns reddish brown, giving the leaf or stem a spotted appearance.

Ordinarily the feeding of the nymphs is more injurious to a plant than that of the adults because usually there are to be found a great many more nymphs than adults on the same plant. It is believed that nymphs, after hatching from the eggs, often remain on the same plant during the first two or three instars. The feeding of the nymphs in grain is practically limited to the throats of the plants; however, they will feed on almost any tender or succulent part. In the case of alfalfa the feeding is done on the underside of the leaves and upon young tender stems. The adults feed freely upon

the stems and leaves, especially along the midribs, of grains, grasses, and alfalfa. Their feeding causes very young alfalfa plants to grow slim and spindling.

Another form of injury is produced by the adult female in puncturing and constructing in leaves and stems the pockets for oviposition. A slit is made in the leaf or stem, and the eggs are thrust through this slit under the epidermis. These egg pockets cause a distortion of the surrounding plant tissue which later turns yellow. When four or five egg pockets are made in a single leaf of a young grain plant the injury resulting to the leaf is quite marked, and when several leaves on the same plant, as is often the case, are so affected, the entire plant is bound to be more or less injured.

The third mode of injury is caused by spores of fungous diseases gaining entrance to the plant tissue through the feeding punctures and egg-pocket slits. It is more than probable, but as yet has not been positively determined, that jassids themselves carry and disseminate the spores of rust and other fungous diseases.

DISTRIBUTION.

As Prof. Osborn has noted,[1] this jassid has an extremely wide distribution. In this country it ranges from the Atlantic to the Pacific and from the strictly boreal portions of Canada south into Mexico. It has been recorded by assistants of the Bureau of Entomology from 35 States, representing all sections of the United States excepting New England, where, although in all probability it occurs, no available records show its presence.

FOOD PLANTS.

The author has taken the nymphs and adults in large numbers from wheat, barley, oats, alfalfa, bur clover (*Medicago denticulata*), sour clover (*Melilotus indica*), Johnson grass (*Sorghum halepense*), wall barley (*Hordeum murinum*), and many other native grasses of the south and southwest. The adults alone have been observed feeding upon kafir corn, sorghum, cowpeas, vetch, and Bermuda grass. In addition to this list Prof. Osborn reports [1] having taken the species from rye, bluegrass, and brome grass. Other assistants of the Bureau of Entomology have noted the species as feeding on corn and timothy. It is very likely that a complete list of food plants would include several other cultivated crops and innumerable weeds.

DESCRIPTION.

The following is a copy of the technical description (*Tettigonia mollipes*) by Say, published in 1831:

Body yellow; head elongated, acute before; beneath the eyes a brown line, which is contained on the pectus; thorax green, a broad anterior and lateral yellow margin;

[1] Op. cit., p. 57.

scutel greenish-yellow; hemelytra green; nervures paler; exterior and apical margins pale yellow or whitish; a pale yellowish, capillary, oblique line from the humerus to the inner margin; tergum black-purple, lateral edge and tip yellow.

Length to the tip of the hemelytra over three-tenths of an inch.

A common species.

A simple description which will enable the farmer or uninitiated to recognize the species in its several stages is given below:

ADULTS.

(Fig. 1, *a–f.*)

Color bright grass-green, head very sharply pointed, of a slightly lighter green than body. Face marked with oblique lines. Males noticeably smaller than females, and with black venter. Venter of female lighter than wing covers.

EGGS.

(Fig. 1, *k.*)

The eggs are white; when first deposited they are rather transparent, later becoming opaque. They are irregularly elongate in form, comparatively blunt at both ends, and about three times as long as wide. The head end of the egg is somewhat bulging. Eyes of the immature nymph show through the eggshell as red spots a few days before hatching takes place. Table I, taken from the notes of Mr. V. L. Wildermuth, an assistant of the Bureau of Entomology, gives the egg measurements.

TABLE I.—*Measurements of eggs of the sharp-headed grain leafhopper.*

Egg.	Length.	Maximum width.	Minimum width.
	Mm.	*Mm.*	*Mm.*
1	1.40	0.35	0.15
2	1.25	.40	.10
3	1.40	.40	.125
Average	1.35	.38	.125

NYMPHS.

(Fig. 1, *g–j, l.*)

In general the nymphs resemble adults in shape and color, the most noticeable difference being in absence of wings and wing covers, and in size.

First-instar nymphs (fig. 1, *l*).—Color light yellow-green, uniform but somewhat darker on dorsal side of last two abdominal segments. Legs a cottony white. One dorsal stripe of lighter yellow running

entire length of body from vertex to tip of abdomen. Two dark spots at rear of head, one on either side of dorsal stripe. No hairs

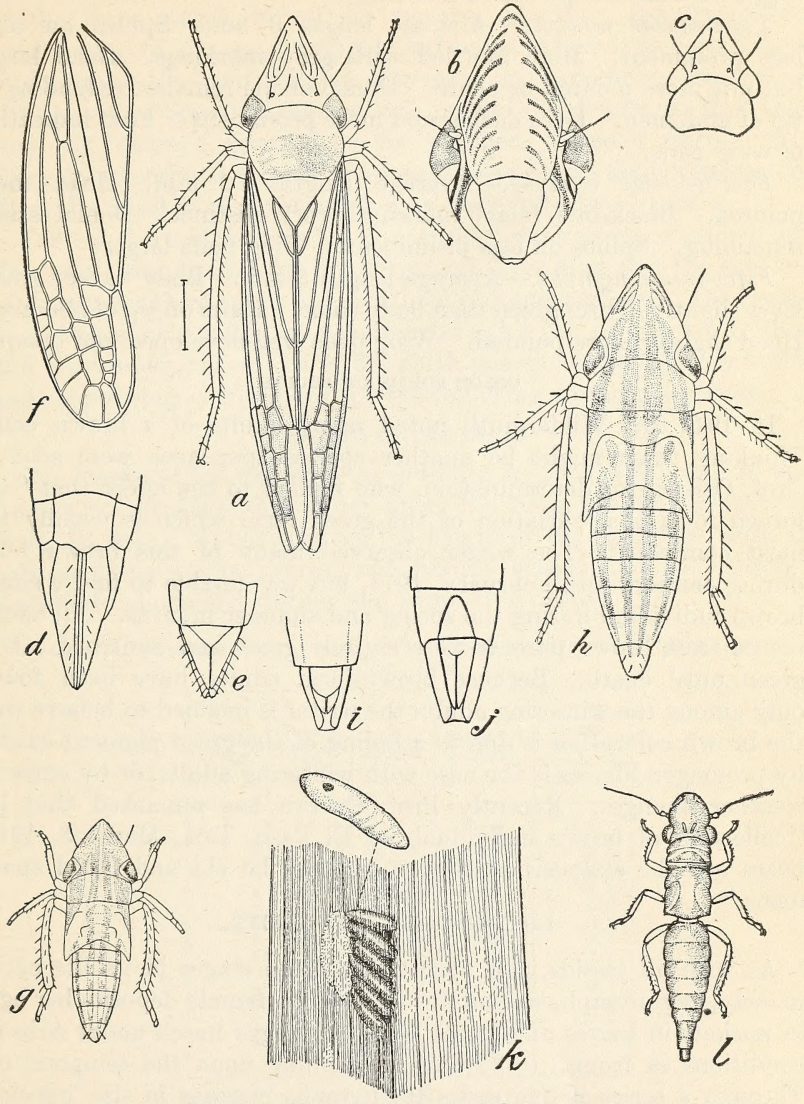

FIG. 1.—The sharp-headed grain leafhopper (*Draeculacephala mollipes*): *a*, Adult from above; *b*, face; *c*, vertex and pronotum; *d*, female genitalia; *e*, male genitalia; *f*, wing; *g*, *h*, nymphs; *i*, anal segment of last-stage nymph, showing genitalia of male; *j*, anal segment of last-stage nymph, showing female genitalia; *k*, eggs inserted in blade of wheat; *l*, freshly-hatched nymph. *a–k*, Enlarged; *l*, greatly enlarged. (*a–h*, From Osborn; *i–l*, original.)

or spines. Head very blunt, in contrast with nymphs of later instars. Average 1.5 mm. in length.

Second-instar nymphs.—Average length 2.5 mm. Head more pointed or acute. Black-line facial markings becoming distinct. Light median dorsal stripe remaining.

Third-instar nymphs.—Average length 3 mm. Spines on hind legs prominent. More mottled with gray markings. Head larger but not more pointed or acute. Dorsal stripe remains, extending to tip of abdomen. Eyes darker and more prominent. First indication of wing pads.

Fourth-instar nymphs.—Average length 4.2 mm. Head more pointed. Black-line facial markings very distinct. Dorsal stripe remaining. Spines on legs prominent. Wing pads larger.

Fifth-instar nymphs.—Average length 5 mm. Body darker green. Eyes slightly lighter green than body color. Hairs on tip of abdomen. Head slightly more pointed. Wing pads well developed and opaque.

COLOR FORMS OF ADULTS.

In 1913 Mr. Wildermuth noted many adults of a brown color. Thinking these might be another species specimens were sent to Prof. Osborn for determination, who replied to the effect that "the brown form is a variation of the green form which is usually the most common." The writer observed many of this brown form during January and February, 1914, but was unable to find a single brown individual during the spring and summer months. All adults reared from brown parents were entirely green and remained a true green until death. Because brown-form adults have been found only among the wintering adults the writer is inclined to believe that the brown coloration is due to a fading of the green pigment caused by prolonged life, as is the case with wintering adults, or by extreme weather changes. Recently Prof. Osborn has remarked that his "collection of brown individuals at El Paso, Tex., March 3, 1910, bears out the supposition that these may be old and faded specimens."

LIFE HISTORY AND HABITS.

As with all jassids, this species has three stages in its life cycle, namely, egg, nymph, and adult. The adult female deposits her eggs in pockets in leaves and stems, and these eggs hatch under Arizona conditions in from 3 to 35 days, depending upon the temperature. Through a series of five molts the nymphs increase in size, develop, and with the last molt transform to the adult. The length of the nymphal stage, as with the egg stage, depends largely upon the temperature, averaging 30 days in Arizona.

NUMBER OF GENERATIONS.

The number of generations a year will vary in different parts of the country according to the various climates, and is likely to fluctuate from year to year in accordance with seasonal variations. Prof.

Osborn remarks that in Ohio "there are clearly two distinct generations annually." In the Southern States, where there are more generations, these are not so clearly distinct, due to an overlapping of the three stages during the summer months. Because of this overlapping of the egg, nymphal, and adult stages it is very difficult to determine the exact number of generations from field observations. By the use of breeding cages it was possible to determine that there were six distinct generations for southern Arizona during 1914. The cage experiments checked up very closely with field observations. Thus the number of generations may vary from two to six.

For southern Arizona the first spring generation extended over February, March, and April; the second, over May and the first half of June; the third, over the last half of June and July; the fourth, over August; the fifth, over September; and the sixth, over October and November, the adults of the sixth generation living over winter and ovipositing in February for the following spring generation.

LENGTH OF EGG STAGE.

The length of the egg stage in southern Arizona was found to vary from 3 to 35 days, depending upon the temperature, the average being 12 days. Table II gives the length of the egg stage, with the corresponding temperatures, and plainly shows that the length is materially shortened during the summer months.

TABLE II.—*Length of the egg stage of the sharp-headed grain leafhopper, Tempe, Ariz., 1914.*

Number of eggs.	Date of oviposition.	Date of hatching.	Length of egg stage.	Average mean temperature during egg stage.
			Days.	°*F.*
4	Feb. 4	Mar. 11	35	59.0
16	Feb. 13	...do.....	26	61.7
6	Feb. 19	Mar. 12	21	67.4
6	Mar. 5	Mar. 20	15	65.9
3	Apr. 5	Apr. 20	15	70.4
5	May 8	May 16	8	74.3
7	May 11	May 18	7	74.3
8	...do.....	May 16	5	74.1
10	June 19	June 28	9	85.0
9	July 29	Aug. 1	3	93.0
14	Aug. 28	Sept. 2	15	82.8
20	Oct. 1	Oct. 5	4	71.0
		Average.....	12.75	

SUMMARY, SHOWING CONDENSED AVERAGES.

When length of egg stage averaged—	The average mean temperature was—
Days.	°*F.*
27.3	62.7
15.0	68.1
8.0	77.8
4.2	80.2

From the notes made by Mr. V. L. Wildermuth at Tempe, Ariz., during February and March, 1913, the length of the egg stage is shown in Table III to be practically the same as found by the writer for those months.

TABLE III.—*Length of egg stage of the sharp-headed grain leafhopper, Tempe, Ariz., February and March, 1913.*

Date of oviposition.	Date of hatching.	Length of egg stage.
		Days.
Feb. 21	Mar. 29	36
Feb. 25	Mar. 18	21
Feb. 27	Mar. 22	23
Feb. 27	Mar. 25	26
Average		26.5

LENGTH OF NYMPHAL STAGE.

As with the egg stage, the length of the nymphal stage varies with the temperature. Prof. Osborn's observations in Iowa show that the nymphal stages extend over from early spring until the latter part of June and from the second week in August until nearly winter. Where the temperatures are higher and the summer season more prolonged the length is considerably shortened. The observations at Tempe, Ariz., show that the average length varies from 20 to 51 days, according to the temperature. Table IV gives the length of the nymphal stage of each of the six generations and the length of each instar.

TABLE IV.—*Length of nymphal stage of the sharp-headed grain leafhopper, Tempe, Ariz., 1914.*

FIRST SPRING GENERATION, MARCH, APRIL, AND MAY, 1914.

Nymph emerged from egg.	Date of first molt.	Length of first instar.	Date of second molt.	Length of second instar.	Date of third molt.	Length of third instar.	Date of fourth molt.	Length of fourth instar.	Date of fifth molt.	Length of fifth instar.	Total length of nymphal stage.
		Days.		*Days.*		*Days.*		*Days.*		*Days.*	*Days.*
Mar. 4	Mar. 14	10	Mar. 25	11	Apr. 4	10	Apr. 13	9	Apr. 23	10	50
Do.	Mar. 10	6	Mar. 18	8	Mar. 30	12	Apr. 8	9	Apr. 20	12	47
Mar. 10	Mar. 23	13	Apr. 2	10	Apr. 8	6	Apr. 14	6	Apr. 23	9	44
Do.	Mar. 19	9	Mar. 28	9	Apr. 6	9	Apr. 13	7	Apr. 21	8	42
Mar. 8	Mar. 17	9	Apr. 1	15	...do	5	Apr. 11	5	Apr. 20	9	43
Mar. 11	Mar. 19	8	.....	.....	.....	.....	.....	.....	...do	.....	40
Mar. 10	Mar. 24	14	Apr. 3	10	Apr. 8	5	Apr. 14	6	Apr. 25	11	46
Mar. 12	Mar. 26	14	Apr. 7	12	Apr. 16	9	.....	.....	Apr. 27	.....	45
Mar. 8	Mar. 22	14	Apr. 2	11	Apr. 7	5	Apr. 17	10	Apr. 28	11	51
Mar. 10	Mar. 25	15	Apr. 6	12	Apr. 11	5	Apr. 20	9	Apr. 30	10	51
Mar. 20	Mar. 21	1	Apr. 1	11	Apr. 6	5	Apr. 14	8	...do	16	41
Mar. 6	Mar. 19	13	Apr. 3	15	Apr. 13	10	Apr. 17	4	May 2	15	57
Mar. 12	Mar. 27	15	Apr. 8	12	...do	5	Apr. 20	7	May 5	15	54
Mar. 7	Mar. 19	12	Apr. 1	13	Apr. 7	6	...do	13	May 6	16	60
Mar. 20	Apr. 6	17	Apr. 13	7	Apr. 16	3	Apr. 23	7	May 7	14	48
Mar. 8	Mar. 27	19	Apr. 6	10	Apr. 13	7	Apr. 20	7	...do	17	60
Mar. 20	Apr. 4	15	Apr. 11	7	Apr. 16	5	Apr. 21	5	May 8	17	49
Do.	Apr. 6	17	Apr. 13	7	Apr. 17	4	Apr. 28	11	May 9	11	50
Mar. 21	Apr. 2	12	Apr. 8	6	Apr. 13	5	Apr. 20	7	...do	19	49
Mar. 20	Apr. 4	15	...do	4	...do	5	Apr. 29	16	May 11	12	52
Mar. 18	Mar. 30	12	Apr. 6	7	Apr. 11	5	.....	.....	...do	.....	54
Mar. 10	.....	.....	Apr. 4	.....	...do	7	Apr. 20	9	May 12	22	63
Mar. 20	Apr. 2	13	Apr. 6	4	Apr. 14	8	Apr. 24	10	May 15	21	56
Average[1]		13.2	.....	9.5	.....	6.4	.....	8.2	.....	13.8	50.1

[1] Total of averages of instars, 51.1 days.

TABLE IV.—*Length of nymphal stage of the sharp-headed grain leafhopper, Tempe, Ariz., 1914*—Continued.

SECOND GENERATION, MAY AND JUNE, 1914.

Nymph emerged from egg.	Date of first molt.	Length of first instar.	Date of second molt.	Length of second instar.	Date of third molt.	Length of third instar.	Date of fourth molt.	Length of fourth instar.	Date of fifth molt.	Length of fifth instar.	Total length of nymphal stage.
		Days.		*Days.*		*Days.*		*Days.*		*Days.*	*Days.*
May 15	May 21	6	May 26	5	May 31	5	June 7	6	.....	.....	.....
May 14	May 22	8	May 28	6	June 2	5	June 6	4	.....	.....	.....
May 18	May 25	7	...do.....	3	May 29	1	June 4	6	.....	.....	.....
May 16	May 22	5	May 23	2	May 28	5	June 1	4	June 7	6	22
May 15	May 21	6	May 26	5	May 29	3	June 2	4	June 8	6	22
May 14	May 18	4	May 25	7	June 1	7	.....	.....	.....	.....	.....
May 15	May 21	6	May 26	5	May 28	2	.....	.....	.....	.....	.....
Average [1]		6	.....	4.7	.....	4	.....	4.8	.....	6	22

THIRD GENERATION, JUNE AND JULY, 1914.

June 28	July 1	3	July 6	5	July 11	5	July 14	3	July 21	7	23
Do....	July 2	4	July 5	3	July 13	8	July 18	5	July 23	5	25
Do....	July 1	3	July 6	5	July 12	6	July 17	5	July 22	5	24
Do....	June 30	2	July 7	7	...do.....	5	July 15	3	July 26	5	22
Do....	July 1	3	July 4	3	July 8	4	July 13	5	July 19	6	21
Average [2]		3	.....	4.6	.....	5.6	.....	4.2	.....	5.6	23

FOURTH GENERATION, AUGUST, 1914.

Aug. 1	Aug. 4	3	Aug. 9	5	Aug. 12	3	Aug. 16	4	Aug. 20	4	19
Do....	Aug. 5	4	Aug. 10	5	...do.....	2	Aug. 17	5	Aug. 21	4	20
Do....	Aug. 3	2	Aug. 8	5	Aug. 13	5	Aug. 18	5	...do.....	3	20
Do....	...do.....	2	Aug. 7	4	Aug. 11	4	Aug. 16	5	Aug. 22	6	21
Do....	Aug. 4	3	Aug. 9	5	Aug. 13	4	Aug. 19	6	...do.....	3	21
Do....	Aug. 5	4	Aug. 8	3	Aug. 12	4	Aug. 18	6	...do.....	4	21
Average [3]		3	.....	4.5	.....	3.6	.....	5.1	.....	4	20.3

FIFTH GENERATION, SEPTEMBER, 1914.

Sept. 2 [4]	.....	.....	Sept. 9 [5]	.....	.....	.....	Sept. 18 [6]	.....	Sept. 28 [7]	.....	26

SIXTH GENERATION, OCTOBER AND NOVEMBER, 1914.

Oct. 6 [8]	Oct. 11 [9]	.....	Oct. 17 [9]	.....	Oct. 23 [9]	.....	Oct. 30	.....	Nov. 9	.....	34

[1] Total of averages of instars, 25.5 days.
[2] Total of averages of instars, 23 days.
[3] Total of averages of instars, 20.2 days.
[4] About 20 nymphs.
[5] Nymphs in second and third instars.
[6] Nymphs in fourth instar.
[7] Sixteen adults.
[8] About 15 nymphs.
[9] About this date.

From Table IV it will be seen that it took the nymphs of the fourth generation the shortest time for development and growth, being an average of 20 days from egg to last molt. While the lengths may vary from season to season and from year to year, it is evident that during the summer months nymphs develop in about half the time of those of the first spring generation.

From the notes made by Mr. Wildermuth at Tempe, Ariz., in 1913, for the first spring generation the average length of the nymphal stage during March and April is shown to be 40 days, a few days less than that obtained the following year by the writer. (Table V.)

TABLE V.—*Length of nymphal stage of the sharp-headed grain leafhopper, Tempe, Ariz., 1913.*

Nymphs emerged from egg.	Adults emerged from last nymphal molt.	Length of nymphal stage.
		Days.
Mar. 18	Apr. 20	33
Mar. 24	May 5	42
Mar. 27	do	39
Mar. 24	May 10	47
Average		40.25

HIBERNATION AND WINTERING.

Prof. Osborn [1] states that "hibernation seems to occur in all stages from the egg to the adult, although the great majority must pass the winter in the egg stage." At Tempe, Ariz., the writer searched diligently during January, 1914, for all stages of the species but found only adults. No eggs were deposited in cages either in or out of doors until February 4. Dissections of adult females during January showed them to be full of immature eggs. An experiment was carried on in which young nymphs were submitted to a temperature of 35° F. for 18 hours, at the end of which all nymphs were dead, showing that it is improbable that young nymphs could ever withstand the winter. Mr. F. H. Gates, another assistant of the Bureau of Entomology at Tempe, reports having taken adults on a number of days during November and December, 1914, and January, 1915. On December 15 he took several nymphs which were probably in the fourth or fifth instar. From his observations it would seem that the nymphs which had attained the fourth or fifth instar by late fall might survive the winter, although up to December 15 there had been no really cold weather at Tempe, the minimum temperature recorded to that date having been 28° F. At Charleston, Mo., during November and December no eggs or nymphs could be found, while the adults were present and active on warm days. It seems safe, therefore, to assume that the species winters over principally in the adult stage throughout the Southern States and in all probability the same holds true throughout the country.

GENERAL ACTIVITIES OF THE ADULTS.

The adults are exceedingly quick of movement, and might well be described as restless. They are easily disturbed or frightened and

[1] Op. cit., p. 58.

jump at the slightest provocation. Because of this fact they are readily caught in the hopperdozer. A clump of tall grass was observed one day to be almost alive with adults, and although there was no wind and apparently nothing to disturb them, the adults suddenly hopped away, all at once. What caused the alarm was not determined. Adults, as well as nymphs, have the habit of dodging to the opposite side of a leaf or stem when approached by a foreign object. On days when there is a strong wind they remain in hiding close to the ground. They are most active during midday, and seldom may they be seen hopping about when dew is on the plants. As the sunlight recedes in the late afternoon they seek shelter under dried leaves and refuse, and at the base of the plant stems. While adults are most active on warm sunny days, during the intense heat of the summer they seek shade and damp places. From a series of observations it has been noted that they are more active on sunny than on cloudy days. Many adults, but not in such numbers as nymphs, can often be found feeding or resting on the same stem or leaf. They both rest and feed with head upward on the plant.

GENERAL ACTIVITIES OF THE NYMPHS.

Nymphs are even more active than adults, doing more running and dodging and less jumping about the plants. They seem to group themselves together; oftentimes 15 to 20 nymphs can be found on 1 square inch of leaf surface, and it is because of this that their feeding becomes injurious to the plant. Mr. Wildermuth has observed that the nymphs commence feeding immediately after hatching. The wind has a stronger effect upon the nymphs than upon the adults, and oftentimes a gust of wind will blow the nymphs several yards. They attempt to keep out of the wind by hiding but are rather easily blown from one plant to another, the throats of young corn plants making a favorite hiding place. When resting the first-instar nymph assumes a characteristic posture, carrying its abdomen slightly curled up and over. The nymphs are very sensitive to heat, and the direct rays of the sun for more than a minute or two on hot days will kill these young stages. Many times they have been observed to burst a bubble of excreta from the tip of their abdomen when disturbed or approached by a foreign object, and Mr. Wildermuth suggests that this may be a means of defense as it is in the case of nymphs of the three-cornered alfalfa hopper (*Stictocephala festina* Say).

OVIPOSITION.

A few days after the male and female adults have emerged from the last nymphal molt copulation has been noted to take place. In 10 experiments carried on in confinement the male died within 1 and 2 days after copulation, although the females, in the same experi-

ment, lived for several weeks after oviposition. The females which overwinter copulate in the fall and may not oviposit until the following spring. The time between copulation and oviposition during other seasons is much shorter, generally about 10 days. As to the manner of oviposition Mr. Wildermuth noted the following: "Her ovipositor was already inserted when found, and she remained so for 22 minutes, being first observed at 1.55 p. m. and withdrawing the same at 2.17 p. m. The angle was changed several times, however, as she inserted the eggs, 7 in all, through the same slit which was about 1 mm. in length. Of course there is no way of knowing how long she had been in the position when found." Females do not necessarily choose protected parts of a plant for oviposition. In all cases noted with grains and grasses the egg pockets were constructed under the epidermis of the upper or inner side of the leaf. Mr. George G. Ainslie noted in Florida that egg pockets in corn are usually to be found in the midribs of leaves and frequently in stalks. In one instance he found an egg slit in a stalk just below the tassel. Eggs within the pocket are placed in a close-fitting row, with their long axes parallel. The number of eggs deposited by a female varies somewhat, but in general it may be said that a single female is capable of depositing between 40 and 50 eggs. The number to a pocket also varies from 2 to 12, with an average of 5, as shown in Table VI.

TABLE VI.—*Oviposition of the sharp-headed grain leafhopper in various plants.*

Plant.	Total number of egg pockets.	Total number of eggs.	Average number of eggs in a pocket.[1]
Wheat	22	102	4.6
Barley	16	85	5.3
Oats	26	155	6
Alfalfa	16	94	5.8
Johnson grass	2	12	6

[1] General average 5.5.

From 18 egg pockets in corn leaves Mr. Ainslie found that the number of eggs per pocket varied from 4 to 20, with an average of 12. This is probably due to the fact that the epidermal tissue of corn leaves is more flexible, thus allowing the construction of larger egg pockets. The period of oviposition may extend over from one to three weeks. Oftentimes a female will construct three or four pockets in one leaf. There seems to be no preference between the different grains for oviposition; however, grains and other broad-leaved grasses, such as Johnson grass, are preferred to alfalfa.

HATCHING OF THE EGGS.

The emerging nymphs burst the end of the eggshell irregularly and emerge head first. Eggs deposited in the leaves hatch sooner than those in stems, as there is not so much plant tissue covering them. Those in stems appear to be inserted more deeply into the plant. The nymphs issue at about the same time, irrespective of the position of the eggs in the pocket.

MOLTING OF THE NYMPHS.

The fourth molting of a nymph was minutely observed, the whole operation taking 20 minutes. The old skin split dorsally along the head and thorax. The head of the nymph first came out, slowly followed by the thorax and abdomen. The abdomen was pulled forward through the old abdominal skin and put through the thoracic slit. As the nymph gradually emerged it leaned or threw its weight backward until the tip of its abdomen was nearly out; then it shifted and spread its legs, taking a firm hold on the leaf surface. After completing the molt it remained still for several minutes.

In examining the last-molt nymphal skin an indication of sex was discovered. Outlines of the ovipositor or genitalia were quite prominent and plain on this cast skin. Attention was then directed to the examination of the last-instar nymphs, and it was found that there is a sex indication with all nymphs of the fifth instar, as the distinction between the male and female genitalia could readily be recognized. (See fig. 1, *i*, *j*.) No sex indications appear in the nymphs of the fourth instar.

ADAPTABILITY OF SPECIES TO CHANGE OF FOOD PLANT.

Only the nymphs of the last two instars can adapt themselves to a change of food plants to any extent. This fact offers a suggestion in the control of the species, in that cutting or grazing their food at the time the nymphs are young will tend to starve them, and thus many will be destroyed.

However, the adults find no difficulty at all in a change. If their food plants be destroyed or cut down, they immediately hunt for substitutes. Starving the adults in the fields would be next to impossible.

MIGRATION.

The species does not spread itself throughout one field or into other fields by the dissemination of the young nymphs, but almost wholly by the flight of the adults. The latter migrate freely from one field to another in search of attractive areas for food and oviposition. Besides this, Prof. Osborn remarks:[1] "The insect shows at times a distinct habit of migration at night." They have been reported

[1] Op. cit., p. 59.

around Columbia, Mo., "in such numbers that they could be gathered up by the bushel."[1] Strong winds in midsummer no doubt are responsible in many cases for what may seem a natural migration.

ENEMIES.

PARASITES.

Probably the most effective enemies of the sharp-headed grain leafhopper are its egg parasites, two species of which were reared in great numbers during the summer of 1914, while the writer was stationed at Tempe, Ariz. Both of these egg parasites were new to science, and Mr. J. C. Crawford[2] has described one as *Gonatocerus gibsoni;* the other Mr. A. A. Girault will describe as *Abbella auriscutellum.* Had it not been for these two egg parasites considerable damage would probably have been done by the jassid during the summer months. One of these parasites, *Gonatocerus gibsoni,* not only held the species in check but practically eradicated the pest in the Salt River Valley of Arizona. In this valley there was from 75 to 95 per cent of parasitism among the eggs of the second generation of the grain jassid between May 15 and June 15. Mr. J. H. Newton, a temporary assistant in the Bureau of Entomology at Tempe, found an 85 per cent parasitism from several hundred egg pockets examined.

Mr. George G. Ainslie, while in Florida during the spring of 1914, reared two species of egg parasites; one of these, reared in considerable numbers, has been determined by Mr. Gahan as *Brachistella acuminata* Ashm. Mr. Ainslie recorded a 79 per cent parasitism among eggs examined. Mr. R. A. Vickery reports having reared many parasites of *Ufens niger* Ashm., as determined by Girault. Five or six were reared from each egg.

There are many parasites which affect the Jassidæ and it is quite likely that this species comes in for its share. Although none has been recorded as having been reared from the grain leafhopper, yet in all probability some of the members of the families Proctotrypidæ and Dryinidæ materially help in suppressing its numbers. Several adults of *Athysanus exitiosus* Uhl. were taken which were parasitized by one of the Proctotrypidæ which appeared in the form of an external sacklike structure within which the parasite sucked the juices from the abdomen of the host. These adults of *A. exitiosus* were swept from fields where the grain jassid was very numerous. In the report of the Hawaiian entomologist and in the papers of Perkins and others may be found accounts of various parasites of the Jassidæ. The dipterous genus Pipunculus contains parasites of leafhoppers and according to Giard they are parasitic especially upon the family Jassidæ. The order Strepsiptera (the twisted-wing insects) contains

[1] Op. cit., p. 20.

[2] Crawford, J. C. Descriptions of new Hymenoptera, No. 9. *In* Proc. U. S. Nat. Mus., v. 48, pp. 577-586, sep. no. 2087, May 3, 1915. *Gonatocerus gibsoni,* new species, p. 586.

parasites upon jassids, but whether or not they have been reared from this species the writer does not know.

ENEMIES OTHER THAN PARASITES.

It is a common sight to see jassids caught in spider webs. Several adults and nymphs of *D. mollipes* have quite frequently been observed in webs, and in more than one instance the writer has seen spiders [1] carrying off dead adults. In Bulletin 108 of the Bureau of Entomology is an account of *Reduviolus ferus* L. as a predaceous enemy of leafhoppers. During the past summer the author observed on two occasions the large agricultural ant (*Pogonomyrmex barbatus* Smith) dragging off an adult grain jassid. Turkeys and toads have been observed catching and eating the adults in alfalfa fields. Prof. Osborn [2] gives a list of over 100 birds whose crops have been examined and found to contain jassids.

FUNGUS.

Prof. Osborn makes mention [3] of a fungus, *Empusa grylli*, which causes an epidemic disease affecting this species. The occurrence of this fungus has been recorded also by Prof. F. M. Webster and Prof. H. Garman.

REMEDIAL MEASURES.

From a study of the habits of this jassid certain simple preventive measures present themselves. In the Salt River Valley of Arizona and in localities of similar conditions the keeping down of wild grasses, principally Johnson grass, along irrigation ditch banks, fence rows, and along roadsides during the summer months will do much in preventing the species from spreading and increasing in numbers. By cutting down or grazing sheep upon these broad-leaved grasses, which afford the preferred summer food, their summer breeding places will be destroyed and an immediate check upon the species produced.

As soon as possible after the grains are harvested the ground should be broken up and planted. If immediate planting is not practical, then the ground should be broken again by either replowing or harrowing after two or three weeks to keep down all native grasses and weeds.

Quoting from Osborn: "The direct treatment which has had the most thorough trial is the use of the hopperdozer, which consists of a sheet-iron strip coated with coal tar. The apparatus is drawn over the grass and the insects, hopping at its approach, fall upon the surface, and thus many are killed." [4] The hopperdozer can be used to advantage while the grain is young and short. It should be used

[1] A list of spiders which feed upon leafhoppers may be found in Bulletin No. 108 of the Bureau of Entomology, U. S. Department of Agriculture, page 35.

[2] Op. cit., p. 28–31.

[3] Op. cit., p. 57.

[4] Op. cit., p. 37.

during the heat of the day when the leafhoppers are most active and jump at the least provocation.

Where the species is infesting pastures or grass lands close pasturing or cutting while it is in the egg stage is advised. Especially would this prove beneficial in the Northern States where the length of the egg stage covers several weeks. So far as the observations of the author go it would appear useless to burn grass for the destruction of the eggs, as when the leaves and stems wither or dry up the eggs do not hatch. Seemingly the eggs must have the moisture of at least the surrounding tissue for hatching. However, the burning of the grasses in which the species may be hibernating in the Northern States would no doubt destroy many of the adults.

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